

WHAT IS CLAIMED IS:

1. An engine, comprising:
 - a tubular housing;
 - a first electromagnetic coil disposed around the tubular housing;
 - a second electromagnetic coil disposed around the tubular housing and axially spaced from the first electromagnetic coil along the tubular housing;
 - a piston disposed within the tubular housing, the piston including magnetic elements;
 - a drive circuit electrically connected to the first and second electromagnetic coils for sequentially energizing the first and second electromagnetic coils to move the piston within the tubular housing;
 - a first magnetic sleeve disposed inside the first electromagnetic coil, the piston being arranged to pass through the first magnetic sleeve during operation;
 - a second magnetic sleeve disposed inside the second electromagnetic coil, the piston being arranged to pass through the second magnetic sleeve during operation; and
 - the first magnetic sleeve being separated from the second magnetic sleeve by non-magnetic material.
2. The engine of claim 1 in which the first magnetic sleeve and the second magnetic sleeve each form part of the tubular housing.
3. The engine of claim 1 further comprising:
 - a third electromagnetic coil disposed around the tubular housing and axially spaced from the second electromagnetic coil along the tubular housing;
 - the drive circuit being electrically connected to the third electromagnetic coil for sequentially energizing the first, second and third electromagnetic coils to move the piston within the tubular housing;

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a third magnetic sleeve disposed inside the third electromagnetic coil, the piston being arranged to pass through the third magnetic sleeve during operation; and

the third magnetic sleeve being separated from the second magnetic sleeve by non-magnetic material.

4. An engine, comprising:
 - a tubular housing;
 - a first electromagnetic coil disposed around the tubular housing;
 - a second electromagnetic coil disposed around the tubular housing and axially spaced from the first electromagnetic coil along the tubular housing;
 - a piston disposed within the tubular housing, the piston including magnetic elements;
 - a drive circuit electrically connected to the first and second electromagnetic coils for sequentially energizing the first and second electromagnetic coils to move the piston within the tubular housing; and
 - the piston having a first bearing extending circumferentially around the piston, and a second bearing extending circumferentially around the piston, the first and second bearings being axially spaced apart along the piston, the piston having reduced diameter, in relation to the diameter of the piston at the first bearing and at the second bearing, between the first bearing and second bearing to define a lubricating sump between the first bearing and the second bearing.

5. The engine of claim 4 further comprising:
 - a first magnetic sleeve disposed inside the first electromagnetic coil, the piston being arranged to pass through the first magnetic sleeve during operation;
 - a second magnetic sleeve disposed inside the second electromagnetic coil, the piston being arranged to pass through the second magnetic sleeve during operation; and
 - the first magnetic sleeve being separated from the second magnetic sleeve by non-magnetic material.

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6. The engine of claim 5 in which the first magnetic sleeve and the second magnetic sleeve each form part of the tubular housing.
7. The engine of claim 5 further comprising:
 - a third electromagnetic coil disposed around the tubular housing and axially spaced from the second electromagnetic coil along the tubular housing;
 - the drive circuit being electrically connected to the third electromagnetic coil for sequentially energizing the first, second and third electromagnetic coils to move the piston within the tubular housing;
 - a third magnetic sleeve disposed inside the third electromagnetic coil, the piston being arranged to pass through the third magnetic sleeve during operation; and
 - the third magnetic sleeve being separated from the second magnetic sleeve by non-magnetic material.
8. The engine of claim 4 in which each of the first bearing and the second bearing comprise axially spaced circumferentially extending ribs, adjacent ribs being separated by a gap for receiving a sealing element.
9. An engine, comprising:
 - a tubular housing, the tubular housing being formed from alternating sections of magnetic material and non-magnetic material;
 - plural electromagnetic coils disposed around the exterior of the tubular housing, with each electromagnetic coil being placed over a corresponding section of magnetic material;
 - a movable magnetic element disposed within the tubular housing; and
 - a drive circuit electrically connected to the plural electromagnetic coils for sequentially energizing the electromagnetic coils to move the movable magnetic element within the tubular housing.

10. The engine of claim 9 in which the movable magnetic element is a piston arranged to reciprocate within the tubular housing.
11. The engine of claim 9 in which the non-magnetic material is ceramic.
12. The engine of claim 9 in which the magnetic material is steel.
13. The engine of claim 1 in which the non-magnetic material is ceramic.
14. The engine of claim 1 in which the magnetic material is steel.

